Available online at www.sciencedirect.com
SCIENCE DIRECT®
Landscape and Urban Planning 70 (2005) 127–141
LANDSCAPE AND URBAN PLANNING
This article is also available online at:
www.elsevier.com/locate/landurbplan

The significance of landscape relic zones in relation to soil conditions, settlement pattern and territories in Flanders

Veerle Van Eetvelde*, Marc Antrop

Geography Department, Ghent University, Krijgslaan 281 S8, B9000 Gent, Belgium

Abstract

Since the 18th century and increasingly since the second half of the 20th century, the transformation of the ancient landscape structures has been devastating. In densely populated and highly industrialized areas, such as Flanders (Belgium), only fragments remain from the traditional landscapes of the end of the 18th century. The recently finalized Landscape Atlas of Flanders (2001) gives an inventory of these areas, which are called relic zones and still cover 39% of the country. Their spatial distribution shows a striking way the old communal borders in the periphery of the ancient territories of the villages. Land qualities related to different phases of land occupancy were defined based upon soil and landform. Ten soil associations were overlaid with the relic zone map using ArcView GIS. Distinct soil associations characterize the different historical landscape regions. The spatial correspondence between landscape regions, soil associations and relic zones showed that half of all designated relic zones correspond to at least three major phases and regions of landscape development. The proportion of relic zone areas is extremely low in the urban regions (2.1%), less than average in the sandy area's and higher than average in the polders, loamy regions and alluvial regions. The average patch size of the relic zones is 2.90 km^2 for Flanders but varies from 0.13 to 24.35 km^2. Overall fragmentation is 0.13 patches/km^2 in Flanders, and this varies from 0.04 (loamy plateaus) to 0.19 (coastal zones). Sizes of communal territories in Flanders vary a lot and so do the eccentricity of the settlement site and the proportion of relic zone area in the territory. Larger territories are found in the sandy regions in the north and the west of Flanders and correspond to recent settlements in former forest areas and heath lands. The average CPA shape index (1.523) indicates that square to rectangular shapes are dominant. Most eccentric sites are situated in the larger territories in northern Flanders. Although, the average coverage of relic zone is about 39%, 45 of the 1086 settlement territories used, have no relic zone. The largest proportion (up to 99% of the communal area) is found in territories along the southern periphery of Flanders region. The landscape relics mapped in the Landscape Atlas of Flanders correspond mainly to more stable landscapes in the periphery of communal territories and to settlements located in the periphery of the Flanders region.

Keywords: Cultural landscape; Relics; Land qualities; Territory; Settlement pattern; Flanders

1. Introduction

Increasing pace and scale of landscape changes is observed in most parts of Europe (Klijn and Vos, 2000). Since the Dobřiš Assessment on Europe's environment (Stanners and Bourdeau, 1995), landscapes were put internationally on the agenda. Many researchers in Europe became aware of the growing challenge when trying to preserve any kind of traditional landscape value (Nohl, 2001; Holdaway and Smart, 2001; Green, 2000; Austad, 2000; Wascher, 2000; Wascher and Jongman, 2000; Pedroli, 2000; Antrop, 1997; Meeus et al., 1990). The European Landscape Convention 2000 gives incentives for a

* Corresponding author. Tel.: +32-9-264-4707; fax: +32-9-264-4985.
E-mail address: veerle.vaneetvelde@ugent.be (V. Van Eetvelde).

0169-2046/$20.00 © 2003 Elsevier B.V. All rights reserved.
doi:10.1016/j.landurbplan.2003.10.009

broad and integrated attention for any kind of landscape (Council of Europe, 2000). Not only special sites of interest, which need protection, but also the 'ordinary' landscapes must be taken care of. A first step consists of making an inventory of the actual landscape qualities and their condition. Valuable landscapes need to be mapped and described before they disappear and their hardly known qualities become lost. Many of the valuable cultural landscapes still witness the traditional rural landscape of before the important changes since the 18th century caused by the industrial revolution.

In Flanders region (Belgium), the relics of the traditional landscapes were mapped and described in a GIS database (Hofkens and Roosens, 2001). The actual road network, field systems, and settlement patterns and the occurrence of many small elements, such as ditches, embankments, tree rows were compared to their representation on historical maps of the 18th and 19th century. Relic zones refer to areas, which still show former landscape structures and elements in a legible and coherent manner. The final map shows a striking association of these zones with the old communal borders and suggests that the change—or better the landscape stability—also depends upon the successive phases of settlement and the territorial organization in the landscape (Fig. 1). This spatial distribution also indicates that the relic zones probably represent mainly peripherical zones and more recent land occupation.

This article analyses the spatial distribution of the landscape relic zones in Flanders in relation to the physical land qualities defined by soil conditions and slope, and cultural landscape aspects such as the settlement site, the communal territories and boundaries in the different landscape regions. The diversity of the cultural landscapes in Flanders is exceptionally high because land qualities vary over short distances, in particular soils and slopes. Also, the long history of land occupancy is complex and shows successive phases of land (re)organization so that different landscape regions can be recognized. The main research question focuses upon the meaning of the designated landscape relic zones of the traditional landscapes in relation to the landscape diversity and history.

2. Study area and materials

2.1. Flanders: highly urbanized but still a great landscape diversity

Belgium possesses an astonishing diversity of landscapes, although it is a small country (Antrop, 1997).

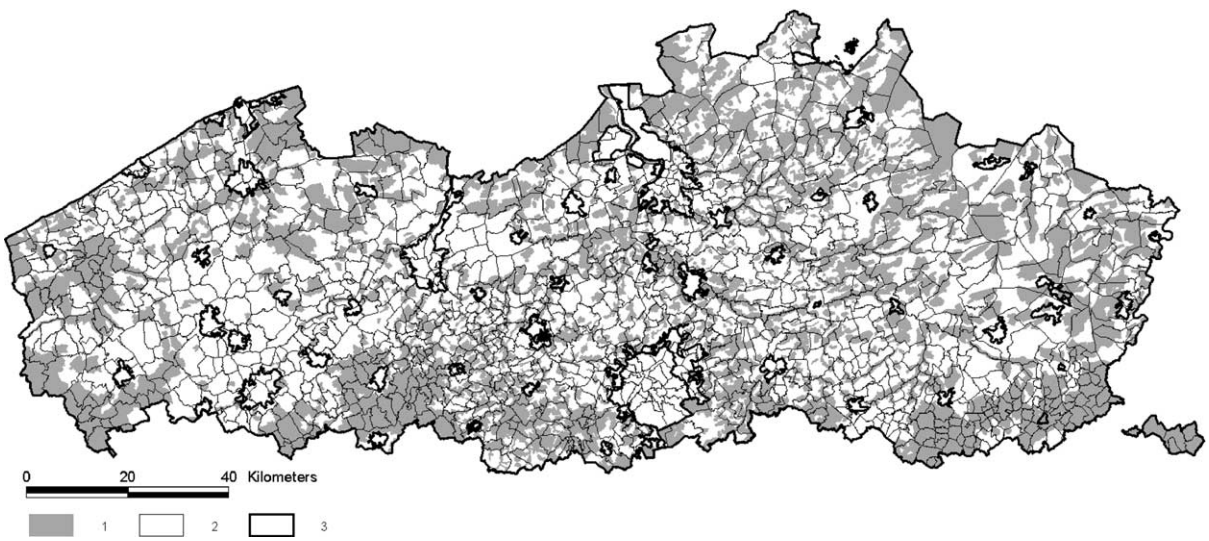


Fig. 1. Relic zones of the Landscape Atlas of Flanders overlaid by the ancient communal division. (1) Relic zones, (2) communal territories, (3) main urban agglomerations.

Two main factors explain this. First, there is the great variety in natural conditions. Deposits range from the early Palaeozoic, strongly influenced by the Hercynian orogeny, up to the whole Quaternary, influenced by periglacial climatic changes. Consequently, natural resources, and soil conditions show a great diversity that humans used in a continuously varying way since the early agrarian occupation of the land, which started here around 4000 BC. The geographical situation explains the second major factor of landscape development. The northern and central parts of the country, the actual Flanders region, form a narrow corridor of lowlands between the North Sea and the mid-European Hercynian mountain belts. During history, this corridor of lowlands was the passage for the most important human movements from south to north and vice versa, and also from east to west. Thus, an exceptional cultural diversity was added to the natural one.

In medieval times, the towns in Flanders belonged to the most important ones in Europe. Textile production and trade were important factors for their growth. They had important influence upon the surrounding rural landscape. Vast grazing land was necessary for the growing sheep flocks; special crops were needed for dyeing the cloths and a higher food production was needed for the increasingly growing population. Rapidly, the initial pattern of small farming villages changed and a hierarchical and networked settlement pattern emerged. In the 18th and early 19th century, some cities started to grow rapidly by industrial expansion. Canals and the railway changed accessibility profoundly, mainly driven by improving the access to the new coal mining areas and to the main maritime harbors. This is the beginning of the deterioration of the traditional rural countryside.

Today, Belgium is highly urbanized: in 1995, 97% of the population was considered as urban (United Nations Centre for Human Settlement, 1996). Belgium counts 15 urban regions of at least 80,000 inhabitants and many large and small towns and urbanized villages. Flanders is the most urbanized region with an average population density of about 431 inhabitants per square kilometer (Antrop, 2000). The impact of urbanization and transport infrastructure upon the traditional rural landscape is extreme. The traditional landscapes are defined as the landscapes of the pre-industrial period, which were mainly conditioned by natural factors, such as topography, geological structure, and soil conditions, and by cultural differences which were mainly influenced by differences in land ownership and policy according to land reclamation and land organization. In Flanders, 124 different traditional landscapes have been recognized (Antrop, 1997, 2001). They group into 22 main landscape regions (Fig. 2) (http://www.geoweb.rug.ac.be/services). An inventory of the actual condition of the traditional

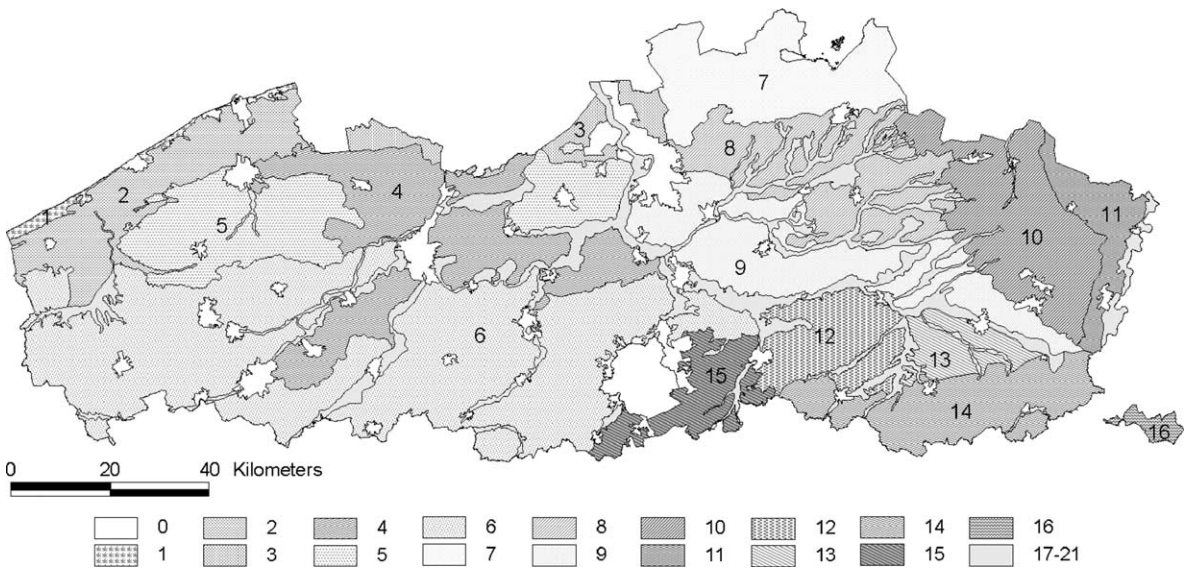


Fig. 2. Landscape regions based upon the classification of the traditional landscapes of Flanders.

landscapes resulted in the mapping of landscape relics and the creation of the Landscape Atlas of Flanders.

2.2. The Landscape Atlas of Flanders

The atlas was realized using a holistic method based upon analysis of series of historical topographical maps and aerial photographs (Antrop, 2001). It is available as a GIS-atlas and database (Hofkens and Roosens, 2001).

In Flanders, it is relatively easy to recognize and differentiate the old traditional landscapes from the modern ones, because important historical and cartographic sources are available. The detailed map of count Ferraris made for the Austrian emperor around 1770 is especially valuable, covering the whole of the land that became Belgium in 1830. Not only its detailed scale (1:11,500) is important but also the period it was made: just before the important changes, which started with the Industrial Revolution and thus, the start of the modern urban expansion.

Relics were defined as actual landscape structures and elements that still represent the old traditional ones in a legible and coherent manner. A typology of relics was created based upon spatial properties and not upon the nature or age of the elements. Following categories were recognized:

- *Relic zones*: parts of the landscape that still have the former road network, field system, settlement type of landscape type from a distinct past period.
- *Anchor places or ensembles*: complexes of different features that have a unique history and act as important landmarks in the area.
- *Linear relics*: such as roads, railroads, canals, defensive works, etc.
- Point relics, mostly corresponding to monuments, buildings or special landmarks.
- *View points*: sites were the observer has a good overview of the relic.

For the whole of Flanders region, 515 relic zones have been selected, covering 5303 km^2 or 39% of Flanders (see Fig. 1). Their average area is 10.3 km^2.

3. Methods

The analysis was made in two steps. First, the natural land qualities were assessed according to the history of land reclamation and the organization of the cultural landscape and compared with the occurrence of the designated landscape relic zones. Second, settlement patterns and properties of the associated communal territories and boundaries were compared to the location of the landscape relic zones.

3.1. Interpretation of the natural land qualities

The natural land qualities that were important for the successive phases of landscape formation during history are mainly soil conditions and slope conditions. Belgium has a soil map at scale 1: 20,000 and soil qualities have been studied in detail (Ameryckx et al., 1995; Maréchal et al., 1992; Maréchal and Tavernier, 1974). The Belgian soil classification defines soil series based upon texture, natural drainage, profile development and the lithology of the substrate. These criteria are available as separate digital layers in a GIS (OC GIS Flanders, 2000). Research in archaeology (Vermeulen and Antrop, 2001; Ampe et al., 1996; Vermeulen, 1992) and historical geography (Verhulst, 1995; Daels and Verhoeve, 1979) give evidence for typical land qualities that were important in different periods of land occupation. Thus, the assessment of the early to late phases of land occupation and the creation of different cultural landscapes can be based upon an interpretation of the soil conditions and the relief forms. Ten soil associations were defined (Table 1). For each of the traditional landscape regions, reclassification and overlay of the soil and relief data with the designated relic zones resulted in the area and proportion of relic zones in each of the soil associations (Table 3, Figs. 3–5). The area covered by relic zone was determined for each landscape region and the average size of the relic patches has been calculated as well as the degree of fragmentation, expressed as number of relic patches per square kilometer within the landscape region (Table 2).

3.2. Interpretation of the settlement patterns and territorial shapes

To assess the peripherical situation of the relic zones according to the initial settlement sites, the pattern of settlements and their associated territories was needed. However, the actual administrative division in municipalities is the result of several successive

Table 1
Properties of soil associations and significance for the history of landscape development

Soil association	Soil types	Significance in landscape history
0	Anthropogenetic soils and perturbed soils	Urban and industrial agglomerations and infrastructures
1	Well-drained dry soils: sandy, sandy–loamy, loamy (loess)	Early phase of land occupation: mainly agricultural land
2	Moderately to imperfectly drained wetter soils: sandy, sandy–loamy, loamy	Middle phase of land occupation
3	Poorly to very poorly drained: sandy, sandy–loamy, loamy and complexes	Late phase of land occupation: systematic reclamation and drainage
4	Anthropogenetic plaggen soils	Late phase of land occupation: plaggen-system: mixed agriculture and cattle-breeding
5	(Heavy) clays soils, poorly to very poorly drained	Marginal land, outfields, reforested areas in 18–19th century; alluvial valleys
6	Peat soils–marl and calcareous soils	Exploitation of soils resources
7	Inland and river dunes	Marginal land, outfields, reforested areas in 18–19th century
8	Coastal dunes	Coastal dunes largely build up as seaside resorts since 20th century
9	Polders: clays and sandy soils	Systematic reclamation 10–15th century

Nomenclature of drainage classes according to guideline FAO (1990).

reorganizations and groupings of smaller units. The most important reorganization dates from the 1970s and the resulting territories hardly reflect the ancient townships that were the basic spatial units in shaping the cultural landscape around the initial settlements. Also, for census purposes statistical units were defined, which fortunately still reflect in some way the ancient boundaries and give an indication of the centers of all initial settlements, before urban sprawl extended them largely. These could be reconstructed satisfactory from the current census division as could be tested using some case studies where the results were compared to the information contained in the 18th century Ferraris map. To avoid confusion, some

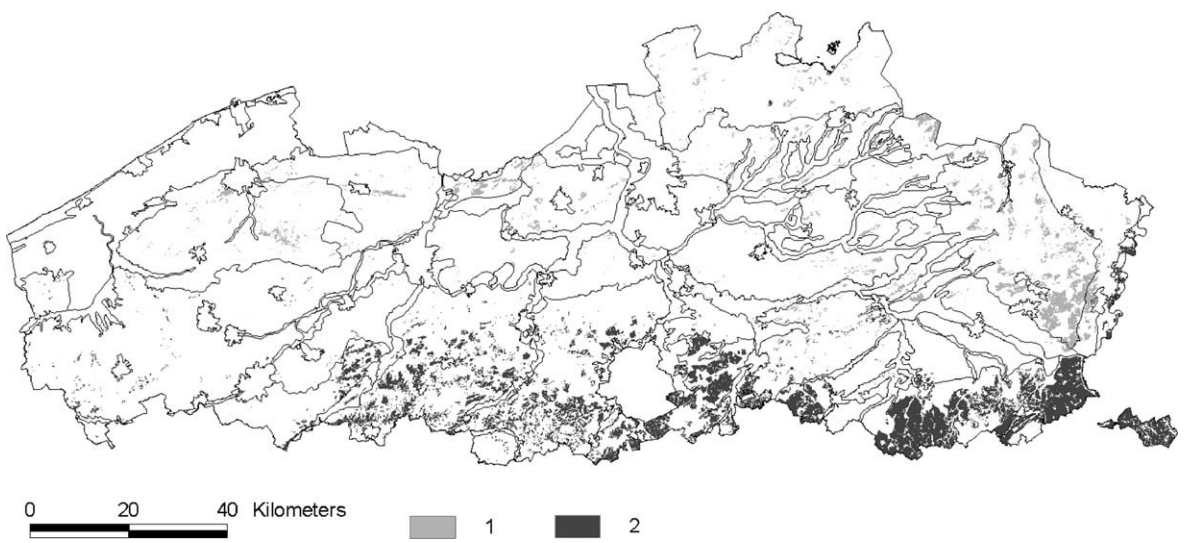


Fig. 3. Correspondence between landscape relic zones and soil association 1 grouping light and well-drained sandy (1) and sandy–loamy and loamy (2) soils. Boundaries correspond to the landscape regions.

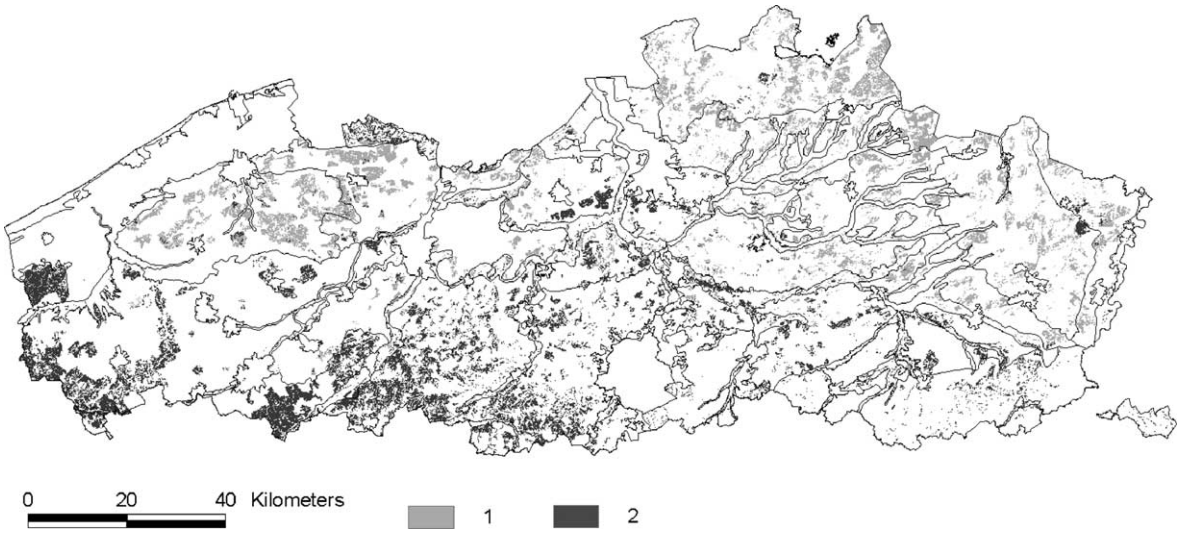


Fig. 4. Correspondence between landscape relic zones and soil association 2 grouping moderately to imperfectly drained sandy (1) and sandy–loamy and loamy (2) soils. Boundaries correspond to the landscape regions.

terminology is used in a specific sense. The term 'settlement' is used for any initial place without consideration of its size and hierarchy (hamlet, village, town or city). Communal territory refers to the former municipal territory, which dates from the creation of Belgium and goes back to ancient administrative divisions.

Besides the area, three other metrics are used to characterize the municipal territories: a shape and an eccentricity index and the border intersection ratio.

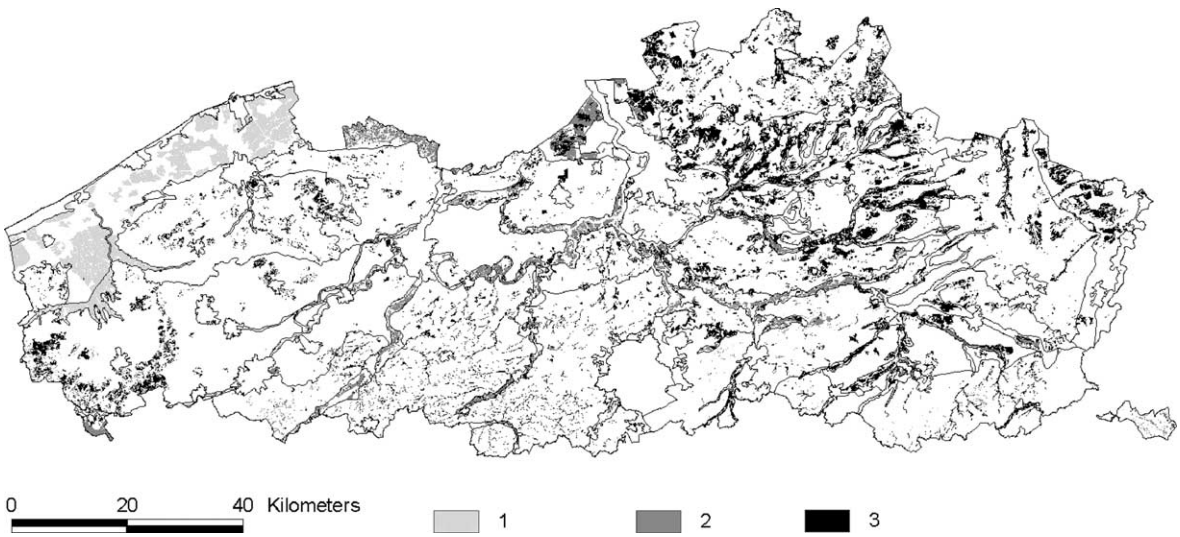


Fig. 5. Correspondence between landscape relic zones and soil associations 3 and 4, grouping poorly to very poorly drained soils and water logged soils (1), associations 5, grouping (heavy) clay soils (2) and associations 9–14, grouping soils of the polders. Boundaries correspond to the landscape regions.

Table 2
Area, fragmentation and distribution of patches of relic zones in the major historical territorial divisions/landscape types

Landscape region	Area (km^2)	Area (%)	Area relic zone (km^2)	Relic zones in Flanders (%)	Relic zones in landscape region (%)	Number of patches of relic zones	Average patch area of a relic zone (km^2)	Fragmentation (patches/km^2)
Urban–industrial regions (0)	757	5.6	16	0.1	2.1	120	0.13	0.16
Coastal zone (1)	67	0.5	33	0.2	49.5	33	1.01	0.49
Coastal polderland (2)	717	5.3	348	2.6	48.5	82	4.24	0.11
Polders of the Scheldt river (3)	231	1.7	175	1.3	75.9	21	8.34	0.09
Flemish Valley (4)	1178	8.7	246	1.8	20.9	129	1.91	0.11
Flemish cuestas (5)	977	7.2	290	2.1	29.7	93	3.12	0.10
Sandy–loamy Flemish hills (6)	3130	23.0	1196	8.8	38.2	325	3.68	0.10
Northern Kempenland (7)	761	5.6	372	2.7	48.9	88	4.23	0.12
Central Kempenland (8)	794	5.8	297	2.2	37.4	154	1.93	0.19
Southern Kempenland (9)	923	6.8	238	1.8	25.8	177	1.34	0.19
Gravel plateau of the Kempenland (10)	840	6.2	410	3.0	48.8	40	10.25	0.05
Maasland (11)	276	2.0	131	1.0	47.5	19	6.90	0.07
Hageland (12)	434	3.2	86	0.6	19.8	72	1.19	0.17
Orchards of Haspengouw (13)	219	1.6	49	0.4	22.4	15	3.28	0.07
Haspengouw (14)	638	4.7	409	3.0	64.1	25	16.36	0.04
Forest land of Brabant (15)	323	2.4	162	1.2	50.2	87	1.87	0.27
Herve (16)	50	0.4	49	0.4	97.1	2	24.35	0.04
Alluvial valleys (17–22)	1269	9.3	794	5.8	62.6	345	2.30	0.27
	13,585	100.0	5303	39.0	39.0	1827	2.90	0.13

The number of landscape region refers to the numbers on Fig. 2. 0, urban-industrial regions; 1 and 2, clay/heavy clay substrate; 3, clay/sandy–loamy; 4, Quaternary deep sandy; 5, sand/clay substrate; 6 and 7, wet sandy; 8, sandy; 9, sandy/sandy–loamy; 10, 11 and 12, sandy–loamy; 13, wet loamy; 14, dry loamy; 15, loamy; 16, loamy; 17–21, clay.

The shape index used was the corrected perimeter area index (CPA) such as defined by Farina (1998) and calculated as follows:

$$\mathrm{CPA} = \frac{0.282P}{A^{0.5}}$$

where A is the area and P the perimeter. The index varies between zero for the most compact shape of a circle and becomes infinite for a line (theoretical the most elongated shape). Hexagons have a CPA = 1.05, squares equal 1.13 and triangles 1.42.

The eccentricity of the location of the settlement center in its municipal territory is expressed by the distance between the settlement site and the spatial center of gravity of the municipal territory (Antrop, 1987, 1988). These distances were normalized between 0 and 100, zero meaning the most central situation of the site.

Finally, the intersection was made between the GIS-map layers of the relic zones and the municipal territorial borders. The ratio of the border length in the relic zones to the total perimeter of the territory was used as an indicator of peripherical situation. The ratio is 0 when no segments of the border of the territory are intersecting a relic zone and 1 when the complete border is intersecting a relic zone. The expected territorial border intersection length with relic zones was estimated as the proportion of the communal perimeter equal to the overall percentage coverage of relic zones in Flanders (39%).

4. Results

4.1. Size and fragmentation of relic zones by landscape region

The proportion of relic zones in the different landscape regions varied from 19.8 to 97.1%, disregarding the urban and industrial areas (only 2.1% is designated as relic zone) (Table 2). This proportion was significantly correlated to the size of the landscape

regions ($r = 0.894$; $P = 0.0000$). The higher values were found in the agricultural landscapes of the loess plateaus (landscape regions nos. 14, 15, 16), the Polderland (nos. 2 and 3), in the small strip of the coastal dunes (49.5% in landscape region no. 1), the northern and eastern Kempenland (no. 7 and 10) and in the alluvial valleys (nos. 11 and 17–22). Medium values were found in the densely populated regions of historical Flanders and Brabant (20.9, 29.7, and 38.2% in landscape regions nos. 4, 5, and 6, respectively).

The average size of the relic patches in the rural areas varied between 1.01 km^2 in the coastal dunes region and 24.35 km^2 in the northeast (landscape region no. 16). Large relic patches were also found in the loess plateaus in the south (nos. 14, 16) and the polderland (nos. 2 and 3).

The fragmentation of the relic zones was expressed for each landscape region as the number of relic patches per square kilometer. The fragmentation varies from 0.05 patches/km^2 (landscape regions nos. 10, 11, and 16) to 0.49 patches/km^2 in the coastal dune region (no. 1).

4.2. Relation to the natural landscape qualities

An ANOVA showed that the traditional landscape regions were significantly different regarding the occurring soil associations (Table 3; $F = 1.6628$; $P = 0.0547$). These regions correspond to different historical landscape provinces. The north of Flanders consists mainly of sandy soils and a clear transition towards sandy–loamy and loamy soils can be noticed to the south. Alluvial soils and the polderland have distinct properties. Natural drainage causes important differences. The most important categories are the well-drained soils and the group of moderately, imperfectly, and poorly drained soils. Most eroded soils are found on the steep slopes. Anthropogenetic plaggen soils are mainly found in the sandy areas in northern Flanders.

Soil association 0, groups perturbed soils in build-up areas, deposits resulting from dredging and also the marshy soils along the important rivers and 82% are associated with the urban–industrial landscapes and wastelands (landscape region no. 1) and covers 12.9% of Flanders (Table 3).

Soil association 1, corresponds to the naturally well-drained soils, which were easy to work and cover about 17.0% of Flanders. These were chosen by the early farmers and are still mainly rural landscapes today. Two groups can be recognized (Fig. 3): the sandy soils in the northern part and the sandy–loamy and loamy soils in the southern part of Flanders. The percentage of relic zones in the southern part is high (more than 50%). In the traditional landscape region of Haspengouw (no. 14) the relic zones form vast areas that correspond to the loess plateau. More to the west (landscape regions no. 6 and 15) a more scattered pattern can be seen in the more dissected hilly landforms with greater soil diversity.

Soil association 2 is associated with moderately to imperfectly drained soils and forms the most important group (35.9% of Flanders). They are found in the sandy soils in the northern part (mainly the landscape regions no. 4–5 and 7), as well as in the sandy–loamy regions in the southwest (landscape regions no. 6) where the geological substrate influences the soil conditions in an important manner (Fig. 4). The percentage of relic zones associated with this soil association is rather low (less than 40%). These soils are associated with specific relief forms (cuesta) and show a very scattered pattern.

Soil associations 3 (17.1%), 4 (4.2%), and 5 (6.7%) (Fig. 5) group the poorly and very poorly drained soils and the heavy clay soils, many correspond to alluvial river valleys. Soil association 6 and 7 group the peat soils (0.08%) and the inland and river dunes (1.8%).

Soil association 8, groups the coastal dunes and is genetic associated with the coastal polders (soil association 9). Relic zones cover about 85.6 and 90.6% of the area of the landscape region. Soil association 9, groups all the soils of the polders, covering 5.3% of Flanders. Relic zones occupy 49% of the coastal dunes, 49% of the coastal polderland and 76% of the polders of the Scheldt estuary.

Following landscape provinces have almost at least half of area designated as relic zone (Table 3): the coastal dunes (49.5%) and the coastal (48.5%) and fluvial (75.9%) polderland, the loess plateaus of Haspengouw (nos. 14, 15, 16, respectively, with 64.1, 50.2, 97.1% relic zone) and the alluvial valleys (62.6%) Relic zones cover only one third of the sandy areas of the historical provinces of Flanders and the Kempenland and between 40 and 50% in the peripherical northern and eastern part. Only 20–25% of the transition region between sandy and loamy soils between

Table 3
Conditional probabilities (%) of relic zones occurring in a soil association by landscape region, the areal distribution of the relic zones and percentage of the landscape regions covered by relic zone

Landscape region	SoilAss0	SoilAss1	SoilAss2	SoilAss3	SoilAss4	SoilAss5	SoilAss6	SoilAss7	SoilAss8	SoilAss9	% Area of all relic zones	% Landscape region that is relic zone
Urban–industrial regions (0)	81.6	5.8	5.9	3.6	0.5	1.2	0.1	0.8	0.5	–	0.3	2.1
Coastal zone (1)	9.4	–	–	–	–	–	–	–	85.6	3.0	0.6	49.5
Coastal polderland (2)	8.0	–	0.5	0.2	–	0.04	–	–	0.6	90.6	6.6	48.5
Polders of the Scheldt river (3)	10.6	0.4	23.2	16.6	5.7	42.7	0.04	0.4	–	–	3.3	75.9
Flemish Valley (4)	5.4	10.6	65.0	13.2	2.7	2.4	0.5	0.2	–	0.1	4.6	20.9
Flemish cuestas (5)	5.8	8.5	61.6	15.9	4.3	3.7	0.1	–	–	0.2	5.5	29.7
Sandy–loamy Flemish hills (6)	5.5	21.0	51.5	16.6	0.1	5.0	0.02	–	–	0.2	22.5	38.2
Northern Kempenland (7)	12.3	4.1	40.5	29.7	8.4	0.2	0.3	4.4	–	–	7.0	48.9
Central Kempenland (8)	11.0	6.7	30.1	23.3	15.9	1.0	0.2	11.7	–	–	5.6	37.4
Southern Kempenland (9)	13.0	7.8	36.9	22.3	12.3	2.6	0.3	4.8	–	–	4.5	25.8
Gravel plateau of the Kempenland (10)	19.4	28.7	27.4	9.0	7.6	–	1.9	5.9	–	–	7.7	48.8
Maasland (11)	9.7	14.9	30.0	27.1	12.7	0.04	3.6	1.9	–	–	2.5	47.5
Hageland (12)	4.9	24.7	37.3	20.3	0.05	10.9	1.7	0.2	–	–	1.6	19.8
Orchards of Haspengouw (13)	6.7	3.3	45.5	38.2	3.2	3.1	–	–	–	–	0.9	22.4
Haspengouw (14)	9.3	76.5	6.6	5.7	–	1.5	0.4	–	–	–	7.7	64.1
Forest land of Brabant (15)	4.7	81.0	8.0	5.4	–	0.8	0.1	–	–	–	3.1	50.2
Herve (16)	4.6	81.3	4.8	2.5	–	6.6	0.1	–	–	–	0.9	97.1
Alluvial valleys (17–22)	12.3	4.0	20.7	28.3	4.4	21.4	4.3	0.4	–	4.2	15.0	62.6
	12.9	17.0	35.9	16.6	4.1	5.2	0.8	1.8	0.5	5.2		39.0

The number of landscape region refers to the numbers on Fig. 2.

Table 4
Summary of numerical properties of communal territories in Flanders and Brussels region

Indicator	Min	Max	Mean	Standard deviation	Coefficient of variation (%)
Area of territory (km^2)[a]	0.43	114.37	12.02	10.97	91
Shape index of territory[a]	1.085	5.505	1.523	0.273	18
Eccentricity index[b]	0.000	100.000	14.344	10.605	74
Relic zones without urbanized regions in territory (%)[b]	0.000	0.986	0.379	0.275	72
Border intersection ratio[c]	0.000	1.000	0.456	0.276	61

[a] All cases $N = 1144$.
[b] Only cases with settlement site $N = 1089$.
[c] Only cases of Flanders region $N = 1117$.

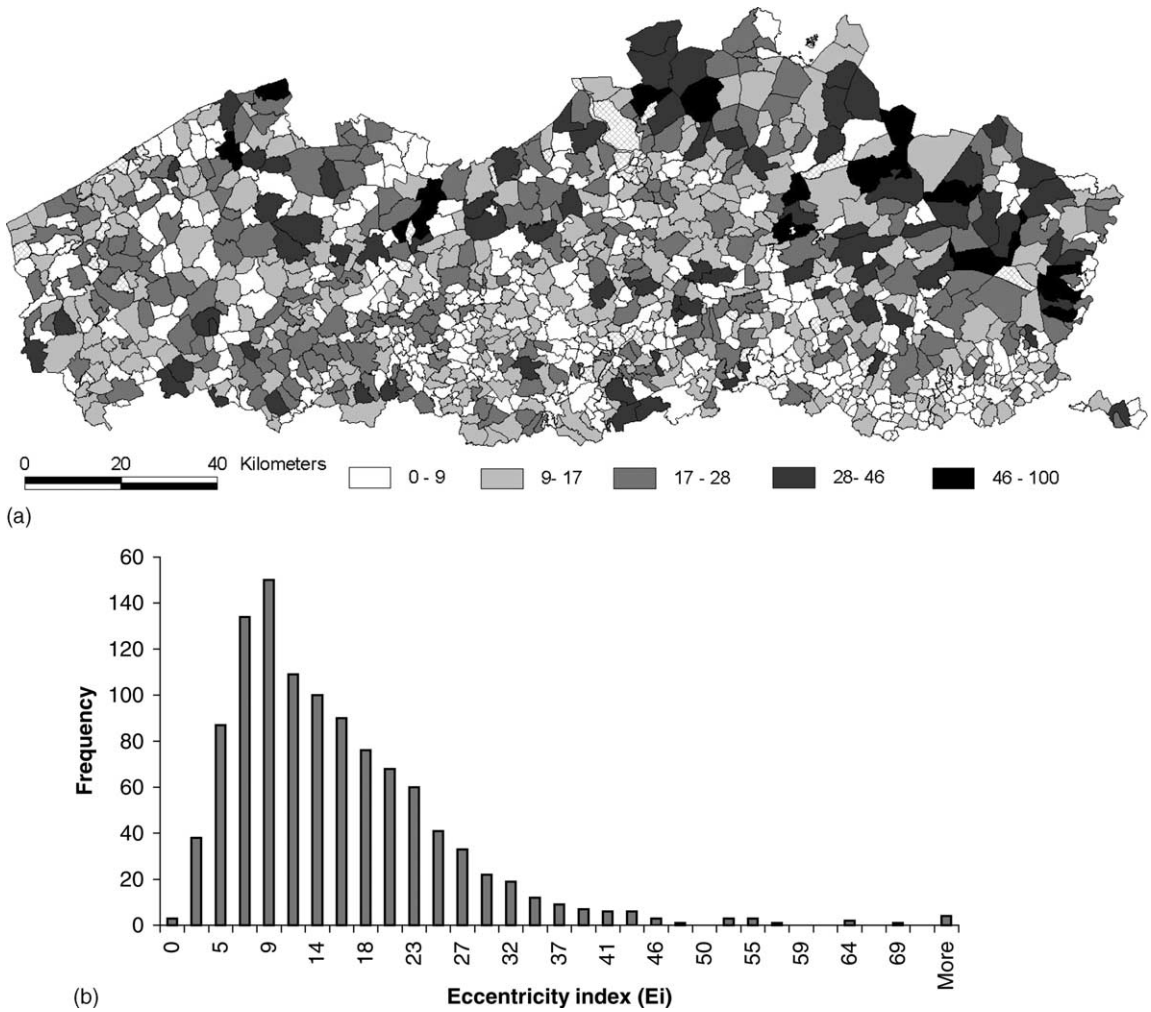


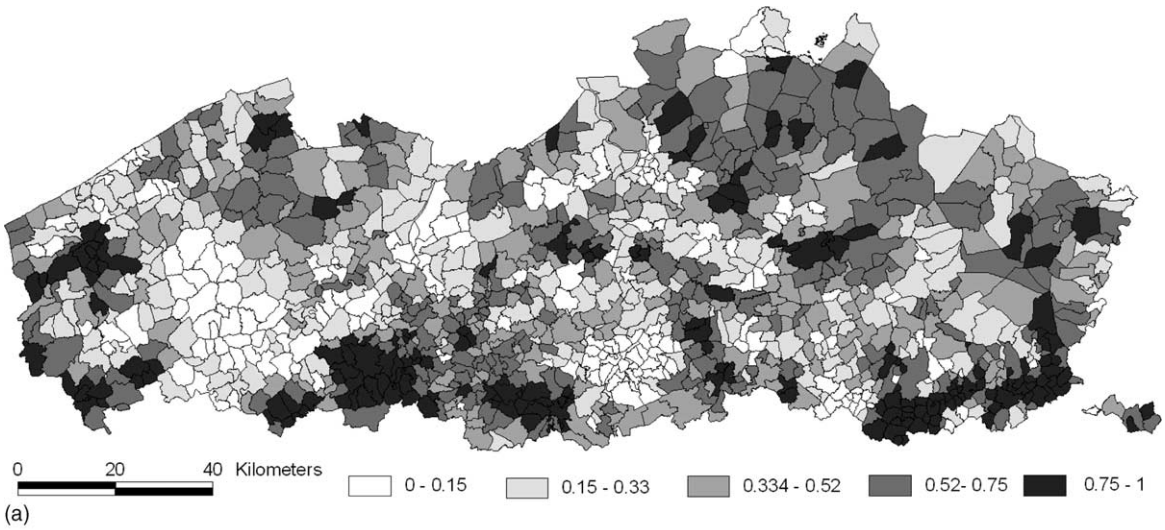
Fig. 6. Eccentricity index (Ei) of settlement site by former municipal territories: (a) map, (b) frequency distribution.

Brussels and Liège (Hageland, landscape region no. 12 and northern Haspengouw, landscape region no. 13) is designated as relic zone.

4.3. Relation to the municipal territories and settlement site

For Flanders and Brussels region, 1144 territories were used in the analysis, of which 1089 had a settlement site. Also initial sites that are now absorbed in the urban agglomerations were used.

Clearly, the size of the communal territories varies a lot: from 0.4 km^2 (Engelmanshoven in landscape region no. 14) to 114 km^2 (Mol in landscape region no. 8 and 10) (Table 4). The smallest are found in the plateau regions with more fertile loamy soils and some correspond to small historical enclaves. The larger territories are found in the sandy regions in the north and the west of Flanders and are recent settlements in former forest areas and heath lands (Fig. 6). The shape index varies from 1.085 to 5.505. The eccentricity of the settlement sites varies a lot (coefficient of variation



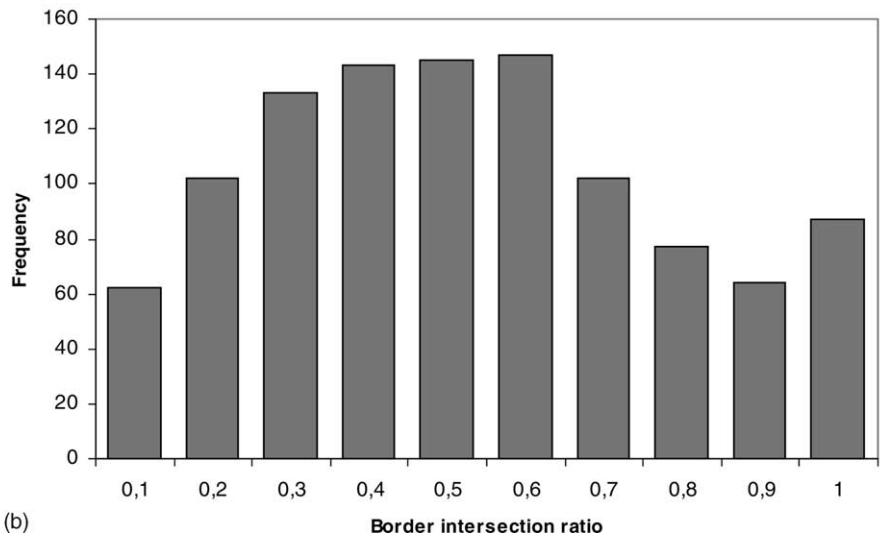


Fig. 7. Border intersection ratio of municipal territories by the relic zones: (a) map, (b) frequency distribution.

of 74%) (Table 4). Most eccentric sites are situated in the larger territories in northern Flanders (Fig. 6).

The average percentage of relic zone within the communal territories is 38%, but varies a lot (coefficient of variation of 72%) (Table 4). Forty-five territories outside the urban agglomerations do not have any relic zone, meaning that the landscape transformed completely the last 300 years. The largest proportion of relic zone is found in small peripheral municipalities (Heuvelland in landscape region no. 6, the Flemish hills) where almost 99% of the territory still has traditional landscape structures.

The average border intersection length is 0.45 but varies a lot. The border intersection length is highly correlated with the proportion of the communal territories covered by relic zones (Table 6, Fig. 7).

5. Discussion

Soil conditions, in particular texture combined with natural drainage and slope conditions was in the past important qualities for land reclamation and the formation of the different cultural landscapes (Verhulst, 1995; Daels and Verhoeve, 1979). Naturally well-drained soils with sandy to loamy texture on flat terrain were chosen for the early agricultural occupation before the 10th century. Extremely dry sandy soils, heavy clays soils, gravely soils and steep slopes remained forested or were used as extensive grazing land creating heath lands in many places. Many of these were reclaimed systematically from the late medieval period and locally reforested during the 18th–19th century. The tidal river estuaries and the coastal marshland were reclaimed from the 11th to 15th century creating new polderland in different phases (Verhulst, 1995). Consecutive inundations made that successive settlement and field patterns were overlaid. The different historical provinces are characterized by distinct traditional landscapes and have particular natural land qualities. The different landscape regions that were formed during history consequently correspond to distinct soil associations.

The area of relic zone in each of the traditional landscapes is significantly correlated with the extension of the region. The largest landscape region (no. 6) accounts for 22.5 of the total area of designated relic zones (Table 2). High conditional probabilities of occurrence of relic zone is found in the soil association 1 in landscape regions nos. 14, 15, and 16 and group 11.7% of all relic zone area in Flanders region. These areas correspond to the fertile loess plateaus that were use by the early farmers (Capenbergs, 1991) and still are important agricultural areas with little disturbance of urbanization and modern infrastructures. Also soil association 2 in landscape regions nos. 4, 5, and 6 has high proportions of relic zones, covering about 32.7% of all relic zone area. These correspond to the moderately to imperfectly drained soils in the historical county of Flanders, which were reclaimed and integrated into the agrarian system only in a later phase (Verhulst, 1995). Soil associations 8 and 9, group the coastal dunes and polders in landscape regions nos. 1 and 2 and group 9.9% of all relic zones. These areas correspond to the systematic land reclamation during the 11th–14th century (Verhulst, 1995). Consequently, more than half of the relic zones correspond to distinct cultural landscapes that are representative for one of the phases in landscape development in Flanders.

Also, the major landscape regions have distinct territorial sizes and shapes. Territorial patterns reflect the natural conditions and the historical phases of development. The smallest territories with most compact shapes appear in the loamy plateau areas in the south of Flanders and larger territories are found on the sandy soils in the north. The average CPA (1.523; see Table 4) is bigger than the hexagonal value (1.126) and indicates that square to rectangular shapes are dominant. Obviously, less compact territorial shapes show a larger eccentricity of the settlement site (see Table 5). Also, larger territories have more eccentric settlement sites, but have proportionally less relic landscapes. Territories with fewer neighbors have higher proportion of relic zones (see Table 6). The high correlation between the border intersection length and the proportion of the communal area covered by relic zones supports the estimation of the expected intersection length using the overall coverage of relic zones in Flanders (39%) and the perimeter length of the communal territories. The comparison of the observed and estimated border intersection length showed no significant difference (one-sided $t = 6.81230$; $P = 0.0000$). This means that about 39% of the relic zones is intersected by communal borders, and therefore, is situated in the territorial periphery, which supports the hypothesis formulated based upon Fig. 1.

Table 5
Pearson correlation coefficients between territorial property variables

	Shape index of territory	Contact nr territory	Eccentricity index	Border intersection ratio
Area territory	0.028	0.395[a]	0.494[a]	−0.065[b]
Shape index of territory		0.232[a]	0.117[a]	0.042
Contact nr. Territory			0.189[a]	−0.010
Eccentricity index				0.007

[a] Correlation is significant at the 0.01 level (two-tailed).
[b] Correlation is significant at the 0.05 level (two-tailed).

This analysis considered all settlements and territories that existed in the 19th century. The comparison with the historical Ferraris map of the end of the 18th century showed that very few smaller settlements disappeared or new ones were created since. However, their age and period of settlement was not taken into account. Older settlements form a framework and cause constraints for the settlement and territorial organization of the newcomers. In Flanders, the colonization phase that made the initial pattern of the actual settlements dates from the Gallo-Roman and early medieval period (Verhulst, 1995). Most are situated on the fertile loamy plateau soils in the southern part of the actual Flanders region and are characterized by small and compact territories. Antrop (1989) described already the relationship between the territorial size and the soil fertility. Many cases were studied of the infilling phase that took place between the 10th and 13th century (Verhulst, 1995; Snacken et al., 1975; Lefèvre, 1964). During the same period a new phase of colonization started on the forested sandy soils in the northern part (Verhulst, 1995; Kakebeeke, 1968). Most of these territories are larger and have less compact shapes. The third phase of concentration and urban competition occurred after 1000 AD. Two aspects are important. First, there is the process of concentration of the population in villages and a reorganization of the land called Dorfballung and incastellamento, which is typical in the whole medieval Europe (Verhulst, 1995). Second, the urban competition starts and the important towns stretch their hinterland over vast areas of rural countryside. Political, social and economic factors gradually disturb the ideal hexagonal lattice (Unwin and Nash, 1992).

Settlement patterns and territories are mainly studied by historical geographers (Muir, 2000). Land use within these territories often shows a core-periphery zoning which in a very general way makes the difference between the more intensively used infields and more extensively used land referred to as outfields (Roberts, 1987). Previous work by Baker (1971) in France and Unwin and Nash (1992) in England used shape indices to characterize townships and periods of land reclamation. Von Thünen (Hall, 1966) formulated a distance model around the village that explained the land zoning in the territory based upon economical factors. Saey (1990) applied Christaller's model on the towns in the area of Flanders south of the city of Ghent and found that the spatial pattern varied gradually from the market to the traffic optimized case and caused differential growth of the places. Antrop (1987) used the gravitation model to create theoretical territories and formulated indices of centrality of the settlements.

Communal territories are considered the best estimated of the real local territories or townships, as called by Aalen et al. (1997) and Unwin and Nash (1992). Many of these borders are based upon much older parish boundaries or ancient political divisions (Baker, 1971). To reconstruct the pre-urban and pre-industrial rural settlement pattern, the historical map of Ferraris (approximately 1770) and the first topographical maps of Belgium dating from the 1850s

Table 6
Pearson correlation coefficients between the proportion of relic landscape in the communal territory and spatial properties of the site and territories

Area of territory	−0.078[a]
Shape index territory	0.038
Contact nr. Territory	−0.112[a]
Eccentricity index	−0.026
Border intersection ratio	0.884[a]

[a] Correlation significant at the 0.01 level (two-tailed).

are the most valuable documents. On the Ferraris map, most towns are still walled and clearly distinct from the rural villages. The map shows only larger political boundaries and no communal borders are indicates, only the parish to which houses belong is given. The map is, however, geometrically distorted. The topographical maps give the oldest geometrically correct position of the communal territories. Also, the actual digital and georeferenced, statistical district map proved to be an interesting source as they gave a good approximation of the initial settlements. A comparative test of the settlement position and size between the Ferraris map and the statistical district map showed also that the size of the centers was much larger on the district map than on the historical Ferraris map. However, the centers of gravity or centroids coincided well. Only very few of the smaller settlements disappeared and some new ones were created. A similar approach was made to create a digital map of the older administrative divisions. The ancient communal territories could be approximated adequately for most rural settlements by regrouping the spatial units on the district map. The comparison between the analogue maps and approximated communal territories showed a good fit with the field patterns and only few and easy recognizable exchanges occurred. Consequently, the centroids of the settlement canters and the reconstructed communal territories proved to be useful for further analysis.

6. Conclusions

Distinct initial settlement patterns and territories characterize the major traditional landscape regions of the late 18th century in Flanders. These become apparent when disregarding the recent urban agglomerations, which wiped most of the traditional patterns away in a devastating manner. These territorial patterns reflect the natural conditions and the historical phases of development. Smaller territories with compact shapes appear on the loamy plateaus in the south of Flanders and larger territories are found on the sandy soils in the north. In Flanders, still many relic areas remain that represent the traditional landscapes dating from the end of the 18th and early 20th century. Today relic zones still cover 39% of the area of Flanders. It can be concluded that many relic zones are situated along the border zones of the former communal territories, and thus represent mainly the former landscapes of the periphery. Most areas around the initial settlements have been urbanized during the last century and fragmented by increasingly important transportation corridors connecting towns and cities. The landscape relics mapped in the Landscape Atlas of Flanders correspond mainly to more stable landscapes in the periphery of communal territories and to settlements located in the periphery of the Flanders region.

References

Aalen, F.H.A., Whelan, K., Stout, M. (Eds.), 1997. Atlas of the Irish Rural Landscape. Cork University Press, Cork.

Ameryckx, J.B., Verheye, W., Vermeire, R., 1995. Bodemkunde. De Pinte.

Ampe, C., Bourgeois, J., Crombé, Ph., Fockedey, L., Langohr, R., Meganck, M., Semey, J., Van Strydonck, M., Verlaeckt, K., 1996. The circular view. Aerial photography and the discovery of Bronze Age funary monuments in East- and West-Flanders (Belgium). Germania 71 (1), 45–94.

Antrop, M., 2001. De landschapsatlas, Methode. In: Hofkens, E., Roosens, I. (Eds.), Nieuwe impulsen voor de landschapszorg. De landschapsatlas, baken voor een verruimd beleid. Ministerie van de Vlaamse Gemeenschap, Afdeling Monumenten en Landschappen, Brussel, pp. 21–43.

Antrop, M., 2000. Changing patterns in the urbanized countryside of Western Europe. Landscape Ecol. 15 (3), 257–270.

Antrop, M., 1997. The concept of traditional landscapes as a base for landscape evaluation and planning. The example of Flanders Region. Lands. Urban Plan. 38, 105–117.

Antrop, M., 1989. Het landschap meervoudig bekeken. Leefmilieu/DNB-Uitg.Pelckmans, Antwerpen-Stichting.

Antrop, M., 1988. Invisible connectivity in rural landscapes. In: Schreiber, K.-F. (Ed.), Connectivity in Landscape Ecology. Proceedings of the Second International Seminar of IALE, vol. 29. Münster, Münsterische Geographische Arbeiten, pp. 57–62.

Antrop, M., 1987. Analyse géographique des sites utilisant des modèles de dispersion spatiale. Archeo-Log 2, 47–64.

Austad, I., 2000. The future of traditional agriculture landscapes: retaining desirable qualities. In: Klijn, J., Vos, W. (Eds.), From Landscape Ecology to Landscape Science. Kluwer Academic Publishers, WLO, Wageningen, pp. 43–56.

Baker, A., 1971. Some shape and contact characteristics of French rural communes. In: Dussart, F. (Ed.), L'habitat et ses paysages ruraux d'Europe. Compte rendu du Symposium, vol. 58, Université, Liège, pp. 13–24.

Capenbergs, J. (Ed.), 1991. Gisteren voorbij. Een archeologische kijk op de geschiedenis van de oudste tijden. Garant, Leuven.

Council of Europe, 2000. The European Landscape Convention. Strasbourg.

Daels, L., Verhoeve, A., 1979. Het Platteland. In: Twintig Eeuwen Vlaanderen, deel 7: De Vlaamse Gemeenschap, pp. 162–177.

FAO, 1990. Guidelines for Soil Description, third ed. Food and Agriculture Organization of the United Nations, Rome.

Farina, A., 1998. Principles and Methods in Landscape Ecology. Chapman & Hall, London.

Green, B.H., 2000. Policy, planning and management initiatives in European cultural landscape conservation. In: Klijn, J., Vos, W. (Eds.), From Landscape Ecology to Landscape Science. Kluwer Academic Publishers, WLO, Wageningen, pp. 57–72.

Hall, P. (Ed.), 1966. Von Thünen's isolated state. An English edition of "Der isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie" (Johann Heinrich Von Thünen, Translator). Pergamon Press, London.

Hofkens, E., Roosens, I. (Eds.), 2001. Nieuwe impulsen voor de landschapszorg. De landschapsatlas, baken voor een verruimd beleid. Ministerie van de Vlaamse Gemeenschap, Afdeling Monumenten en Landschappen, Brussel.

Holdaway, E., Smart, G., 2001. Landscapes at Risk? The Future for Areas of Outstanding Natural Beauty. SPON Press–Taylor & Francis Group, London.

Kakebeeke, A.D., 1968. Some Observations About Parcelling and Habitation in Schadewijk (Eersel), Geografisch Tijdschrift, vol. 2.

Klijn, J., Vos, W. (Eds.), 2000. From Landscape Ecology to Landscape Science. Kluwer Academic Publishers, WLO, Wageningen.

Lefèvre, M.A., 1964. De landelijke bewoningsvormen. Plaat 27, Atlas van België, nat. Comité voor Geografie, Brussel.

Maréchal, R., Ameryckx, J.B., Langohr, R., 1992. De bodems. In: Denis, J. (Ed.), Geografie van België. Gemeentekrediet, Brussel, pp. 242–259.

Maréchal, R., Tavernier, R., 1974. Pédologie. Comments to the sheets 11A and 11B of the National Atlas of Belgium. Nationaal Comité voor Geografie, Brussel.

Meeus, J.H.A., Wijermans, M.P., Vroom, M.J., 1990. Agricultural Landscapes in Europe and their transformation. Lands. Urban Plan. 18, 289–352.

Muir, R., 2000. The NEW Reading the Landscape. Fieldwork in Landscape History. University of Exeter Press, Exeter.

Nohl, W., 2001. Sustainable landscape use and aesthetic perception–preliminary reflections on future landscape aesthetics. Lands. Urban Plan. 54 (1–4), 223–237.

Pedroli, B. (Ed.), 2000. Landscape—our Home. Lebensraum Landschaft. Essays on the Culture of the European Landcsape as a Task. Indigo, Zeits–Freies Geistesleben, Stuttgart.

Roberts, B., 1987. The Making of the English Village. Longman, London.

Saey, P., 1990. Ontwikkelingspolen en verzorgende centra in de geografische opbouw van Vlaanderen, een oefening in toegepaste geografie. Publicaties van het Seminarie voor Menselijke en Economische Geografie, RUG, nr. 18.

Snacken, F., Verhoeve, A., Boon J., Schmook, G., Verhaeghe, F., Wijckmans, M., 1975. Landschapsontwikkeling in historisch-geografisch perspectief. In: Van Miegroet, M. (Ed.), Naar een Groenstrategie voor Vlaanderen, Eerste Vlaams Wetenschappelijk Congres voor Groenvoorziening, Gent, pp. 105–120.

Stanners, D., Bourdeau, Ph., (Eds.), 1995. Europe's Environment. The Dobris Assessment. European Environment Agency, EC DG XI and Phare, Copenhagen.

United Nations Centre for Human Settlement (HABITAT), 1996. An Urbanizing World. Global Report on Human Settlements 1996. Oxford University Press, Oxford.

Unwin, T., Nash, B., 1992. Township boundaries: theoretical considerations and analytical implications. In: Verhoeve, A., Vervloet, J. (Eds.), The Transformation of the European Rural Landscape: Methodological Issues and Agrarian Change 1770–1914. Tijdschrift van de Belg.Ver. voor Aardrijkskundige Studies, LXI, 1, pp. 116–127.

Verhulst, A., 1995. Landschap en landbouw in Middeleeuws Vlaanderen. Gemeentekrediet, Brussel.

Vermeulen, F., Antrop, M. (Eds.), 2001. Ancient Lines in the Landscape. A Geo-Archaeological Study of Protohistoric and Roman Roads and Field Systems in Northwestern Gaul. Peeters, Leuven.

Vermeulen, F., 1992. Transition from antiquity to the early middle ages in the south of sandy Flanders (Belgium): rural settlement. Archäologisches Korrespondenzblatt 22, 421–433.

Wascher, D.M. (Ed.), 2000. The Face of Europe. European Centre for Nature Conservation, Technical Report Series, Tilburg.

Wascher, D., Jongman, R. (Eds.), 2000. European Landscapes. Classification, Assessment, Conservation. European Environment Agency, Technical Report (draft).

Veerle Van Eetvelde (1973) is geographer and planner. She specializes in landscape science, GIS and spatial data structures. At present, she is an assistant at the Department of Geography of the University of Ghent and supervises students' exercises in landscape science. She works on a PhD, analyzing structures and dynamical processes in landscapes. She is co-author of the landscape atlases, active in studies for environmental impact assessment related to landscape and has done research to set up an integrated monitoring system for the Flanders region.

Marc Antrop (1946) is a geographer specialised in landscapes sciences, remote sensing, GIS and planning. He is a professor lecturing at the University of Ghent (Belgium, Flanders). His interest in the landscape is broad and holistic, covering and integrating aspects of landscape history, landscape perception, landscape evaluation and land assessment, landscape ecology and landscape architecture, in particular related to the European landscapes. He is the vice-president for the division of landscape protection of the Royal Committee for Protection of Monuments and Landscapes in Flanders.